UCRL-JC-125659
PREPRINT

Flashlamp for NIF: Russian Variant

A.C. Erlandson
V.A. Gerasimov
V.G. Nikiforov
V.G. Nikolaevskii
L.E. Zapata

This paper was prepared for submittal to the
Solid-State Lasers for Application to Inertial Confinement Fusion (ICF)
2nd Annual International Conference
Paris, France
October 22-25, 1996

November 1996

Lawrence Livermore National Laboratory

Flashlamp for NIF: Russian variant

A.C. Erlandson[3], V.A. Gerasimov[2],
V.G. Nikiforov[2], V.G. Nikolaevskii1[1],
L.E Zapata[3]

[1] Troitsk Institute for Innovation & Fusion Researches
Troitsk, Moscow Reg. 142092 Russia
Phone: 7-095-334-0530, Fax: 7-095-334-5776,
E-mail: vnikol@fly.triniti.troitsk.ru

[2] "Zenit" Scientific Research Institute
Zelenograd, Moscow Reg. 103489 Russia

[3] Lawrence Livermore National Laboratory,
Livermore, CA 94550 USA

ABSTRACT

A variant of the flashlamp for NIF was developed on the base of the experience of manufacture and application of high-power flashlamps in Russia. Features of flashlamp design as well as first test results of the experimental samples are presented.

Keywords: flashlamp, envelope, electrode unit, seal, solder.

1. INTRODUCTION

Working conditions for flashlamps applied in small laser systems differ from those in large high-power laser facilities. A number of extra requirements should be considered both in development of flashlamps and in design of pumping systems for huge lasers like NIF. Physical problems of flashlamp exploitation were discussed in [1]. Among the main technical requirements we should take into account the following:

1. Ease of handling in installation and replacement of the flashlamps in the pumping system.
2. Simple and reliable connection to high-current circuits.
3. Reduction of flashlamp explosion probability, what is especially important for multilamp plane cassettes.
4. Long enough shelf life and a planned period of flashlamp use in the facility.
5. A possibility of simple and inexpensive flashlamp regeneration in the case of working gas replacement.

We developed and fabricated a variant of flashlamp for NIF using our long-standing experience of flashlamp development in Russia. Many flashlamps of different sizes manufactured through Russian technology are successfully employed in powerful laser amplifiers with planar multilamp pumping systems. These flashlamps still show normal operation after 20 years in storage and, in principle, can be easily regenerated if necessary.

In this report we describe a design of the experimental flashlamp for NIF and results of preliminary tests.

2. FLASHLAMP CONSTRUCTION

The experimental sample is a large linear xenon-filled flashlamp with a quartz envelope and two electrode units. The overall dimensions of the flashlamp and features of its design are in accordance with requirements specified for use in NIF.

In this design the electrode unit performs three functions:

-to carry high-current;

-to provide a reliable seal of the envelope;

-to permit evacuation of air from the lamp, as well as filling and replacement of working gas.

The electrode unit consists of an end cap, current-carrying tubular support, electrode tip and titanium cylindrical foil shell. The tungsten electrode tip is connected to the end cap through the long kovar tubular support. All these joints are made by electron beam welding.

The foil shell with diameter equal to outer diameter of the end cap serves as an element of the seal and is fixed on the end cap. The gap between the foil shell and envelope is filled with soft titanium-tin solder. To provide reliable seal and prevent heating of the solder by intensive pumping light we optimized the height of the foil shell.

Evacuation of air from the envelope and filling it with working gas is accomplished through special openings in the tubular support and copper exhaust tube soldered into the end cap of the cathode electrode unit.

We developed special covers with short copper wire leads to connect the flashlamp to outer high-current high-voltage circuit. The cover is tightly screwed on the end cap. This joint provides good electrical contact (the contact resistance is negligible). In addition this cover protects the exhaust tube against occasional damage, keeping easy access to it when flashlamp regeneration is needed.

Principle dimensions of the electrode unit are limited by the overall dimensions of the NIF flashlamp. They are the outer diameter of the end cap, the length of the tubular support, and the electrode diameter. The technology in use allows us to carry out further optimization of this construction if some change in specified dimensions of the flashlamp is acceptable.

The flashlamp envelope is a fused quartz cylindrical tube with the end parts narrowed to the diameter of the end cap. It is fabricated from one piece and have no any exhaust tubes sealed off on its side surface. Smooth narrowing of the envelope over a length of electrode unit decreases a harm effect of gasdynamic perturbations arising during discharge. Rather big dead volume is a reservoir where the electrode and envelope erosion products are condensed. Moreover, such geometry of the end parts permits protection of the sealed places against direct incidence of the discharge light.

One of the key problems of cap-like seal is a heating of the sealing solder in the process of flashlamp operation [3]. Our estimations show that in the regime with an explosion fraction of 0.35 at 400 μsec pulse duration and 3 minute repetition interval the tubular support has enough length to be cooled down by radiation transfer and, thus, to keep the sealing solder at a temperature considerably lower than critical.

3. PRELIMINARY TESTS

We have carried out first tests of the experimental flashlamp at a special stand with a flashlamp driving circuit. External triggering was used. The triggering electrode was made of a metal ribbon and placed 12 mm away from the envelope along the working part of the flashlamp.

One of the important characteristics of flashlamps is the range of operating voltage. It is limited by values of minimum ignition voltage, when the complete discharge starts if the triggering pulse is applied, and critical voltage, when self triggering of the lamp occurs (without applying triggering pulse) [4]. To determine these values a 12 μF feeding capacitor was used at capacitor charge voltage up to 15 kV. A minimum ignition voltage of 3-5 kV and critical voltage exceeding 15 kV were measured for three experimental samples.

Another test was conducted at high energy loading of the flashlamp. In this case the flashlamp driving circuit included a 800 μF capacitor and 17 μH inductance, with total resistance not exceeding 0.003 Ohm. The working voltage was 10 kV. In this test the flashlamp discharge current was measured and then the value of energy delivered to the flashlamp was estimated. Under these conditions the delivered energy was about 34 kJ at 300 μsec discharge pulse duration. Experimental data obtained permits us to note that during discharge the diameter of current-carrying zone was noticeably lower than the envelope bore. The same result was reported in [5].

Final tests of our flashlamp will be performed in LLNL in the near future.

4. ACKNOWLEDGMENTS

The authors gratefully appreciate Prof M.I. Pergament, Prof. N.G. Kovalskii, and Prof. B.A. Konstantinov for their permanent attention and helpful discussions. We thank N.D. Pershin, A.N. Smirnov, and V.I. Baranova for their help in flashlamp design and fabrication. We also thank B.F. Vasilev, V.G. Ponomarev, and N.P. Kabin for their assistance in assembling the experimental stand and conducting the tests.

5. REFERENCES

1. V.G. Nikolaevskii, V.A. Gerasimov, "On experience of flashlamps exploitation in high-power Nd-glass lasers for ICF", First Annual International Conference on "Solid State Lasers for Application to Inertial Confinement Fusion", SPIE, 1995, vol .2633, pp. 583-586.
2. Б.А. Скворцов и др., Авторское свидетельство СССР N 292567 от 23.10.1973г.
3. B. Smith, "Overview of flashlamps and arc lamps", SPIE, 1986, vol. 609, pp.1-41.
4. "Импульсные источники света", под ред. И.С. Маршака, М:Энергия, 1978.
5. H.T. Powell, A.C. Erlandson, K.S. Jancaitis, "Characterization of high power flashlamps and application to Nd:glass laser pumping", SPIE, 1986, vol. 609, pp. 78-94.

This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.